

लो हेड स्लाइड गेट के लिए संरचनागत
डिज़ाइन के मानदंड की अनुशंसाएँ
(तीसरा पुनरीक्षण)

**Recommendations for Structural
Design Criteria for Low Head
Slide Gates**

(*Third Revision*)

ICS 93.160

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FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the Water Resources Division Council.

Slide gates, as the name implies, are the gates in which the operating member (that is, gate leaf) slides on the sealing and/ or load bearing surfaces provided on the frame consisting of gate body with or without bonnets.

This standard was first published in 1970 and subsequently revised in 1978 and 1985. The first revision was made in view of the experience gained during the use of this standard. Modifications made in the first revision included the revision of the permissible stresses in structural materials which have been linked with yield point or ultimate tensile strength of the material and their situation of usage.

As a result of increased use of the standard, suggestions were again received for modifying some of the provisions of the first revised standard and therefore, second revision of the standard was brought out in 1985. In Annex D, two more conditions that is three edges fixed and one (longer) edge free and three edges fixed and one (shorter) edge free, Fig. 12 and Fig. 13 were included in that revision.

Now this third revision is being brought out to incorporate changes and additional clauses in the light of some more experience gained and latest global trends in design specially with reference to coacting width in case of panel construction and figures showing gate installation at crest.

Provision for defreezing may be made for trouble free hoisting of gates in sub-freezing weather conditions.

Provision of hood and flow breakers may be made whenever occasional over topping of gate is expected.

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to the practices in this field in the country. This has been met by deriving assistance from DIN 19704 : 1976 ‘Principles for computation of steel hydraulic plant’ issued by Deutsches Institute of Normung.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*).’ The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN CRITERIA FOR LOW HEAD SLIDE GATES

(Third Revision)

1 SCOPE

This standard lays down the criteria for the design of slide gates for low head installations, that is for water heads up to and including 15 meters over sill. This also covers design guidelines for sliding type stoplogs.

2 REFERENCES

The Indian standards listed in Annex A contain provision, which through references in this text constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on these standards are encouraged to investigate the possibilities of applying the most recent edition of the standards indicated in Annex A.

3 MATERIALS

The materials recommended to be used for different components are given in Annex B.

4 DESCRIPTION OF GATE

4.1 General

The typical installations of a slide gate are shown in Fig. 1 to 4 and 6. These consist of leaf and embedded parts/frame. The embedded parts/frame are embedded in concrete. The frame or embedded parts shall serve:

- a) To transmit water load on the gate leaf to the supporting concrete (structure);
- b) To guide the gate leaf during operation; and
- c) To provide sealing surface.

4.1.1 The low-head slide gates are generally operated by screw/rope drum hoists or hydraulic hoist. For bulkheads or stoplogs, mobile cranes or gantry cranes are usually employed. A typical arrangement of low head stoplogs in multiple units is shown in Fig. 7.

4.2 Gate Leaf

4.2.1 The gate leaf or the operating member is a rigid structure consisting of skin plate suitably ribbed or reinforced. The skin plate may be on upstream or downstream side. Upstream skin plate eliminates accumulation of debris/silt inside the gate leaf. For low head slide gate with upstream sealing and upstream skin plate, see Fig 8.

4.2.2 The gate leaf may be of cast iron, cast steel or structural steel in welded construction. For gates used for emergency or regulating purposes, the gate leaf shall be sufficiently rigid to withstand vibrations and hydrodynamic forces arising from high velocity flow under the gate leaf. The seal-cum-bearing plates which are generally of brass, bronze or gun metal are screwed on the downstream face of the gate leaf for sealing and load transfer purposes.

4.3 Embedded Parts

4.3.1 The embedded parts/frame which provide sealing surfaces, bearing surfaces and guides for the gate leaf are embedded in concrete or masonry and securely anchored. The bearing track generally extends at least one gate height above the opening or water level whichever is lower in case the gate is operated under unbalanced conditions. However, the side guide shall extend up to full travel of the gate.

4.3.2 The embedded parts shall be of structural steel in welded construction. The seal-cum-bearing surface is made of brass, bronze, gun metal or stainless steel in order to have corrosion resisting surface with a low coefficient of friction. This sealing strip may be screwed/welded on to the seal base.

5 REQUIREMENTS

The principal requirements of the slide gates shall be as given below:

- a) These shall be reasonably watertight;
- b) These shall be capable of being raised or lowered within the prescribed time by the hoisting mechanism provided; and
- c) These shall be rigid and reasonably free from vibration.

6 PERMISSIBLE STRESSES

6.1 The permissible value of stresses in structural parts shall be as specified in Annex C.

6.2 The permissible value of stresses in welded connections shall be the same as permitted for the parent material.

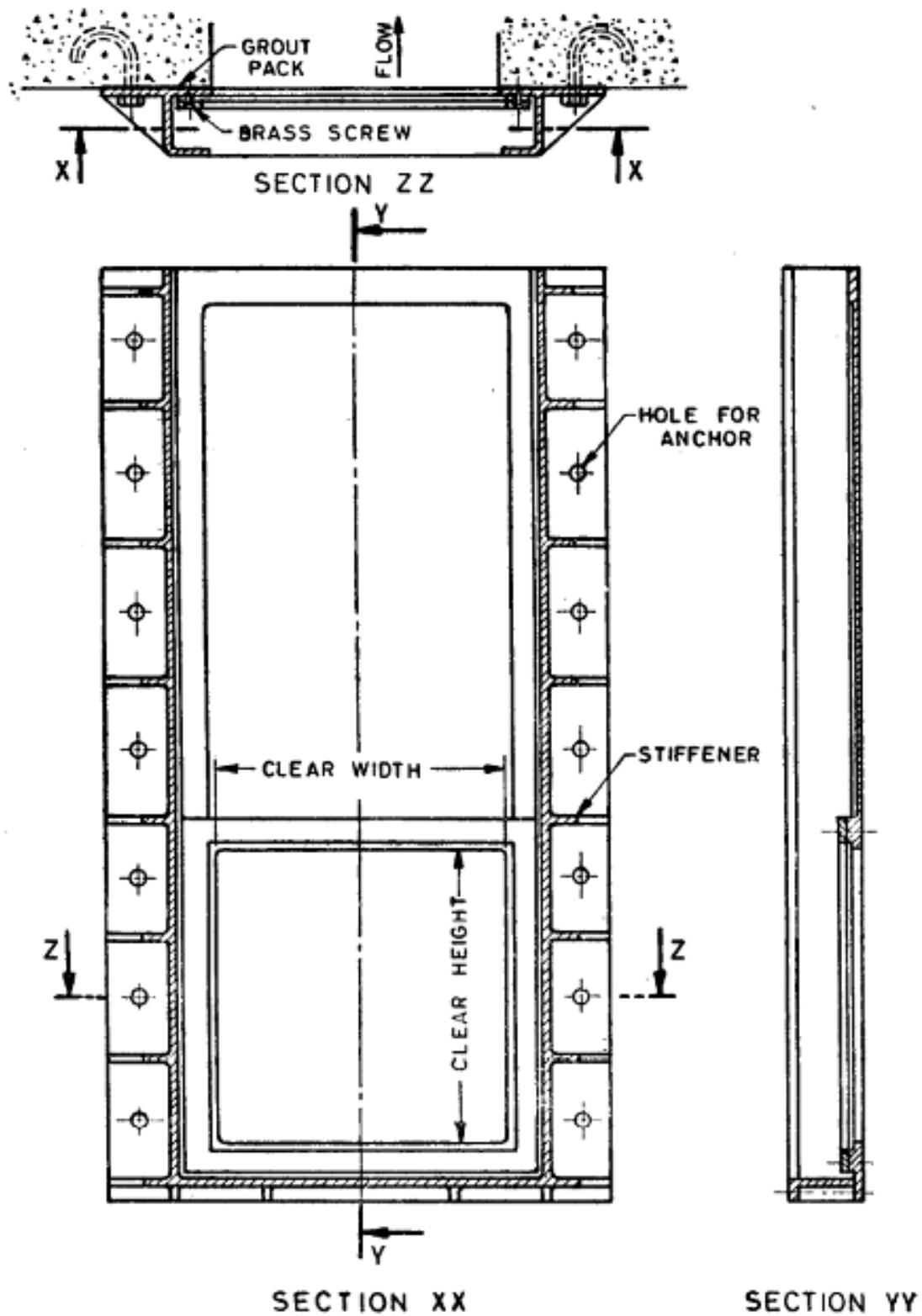


FIG. 1 TYPICAL DIAGRAM SHOWING LOW HEAD SLIDE GATE-FULL EMBEDDED FRAME

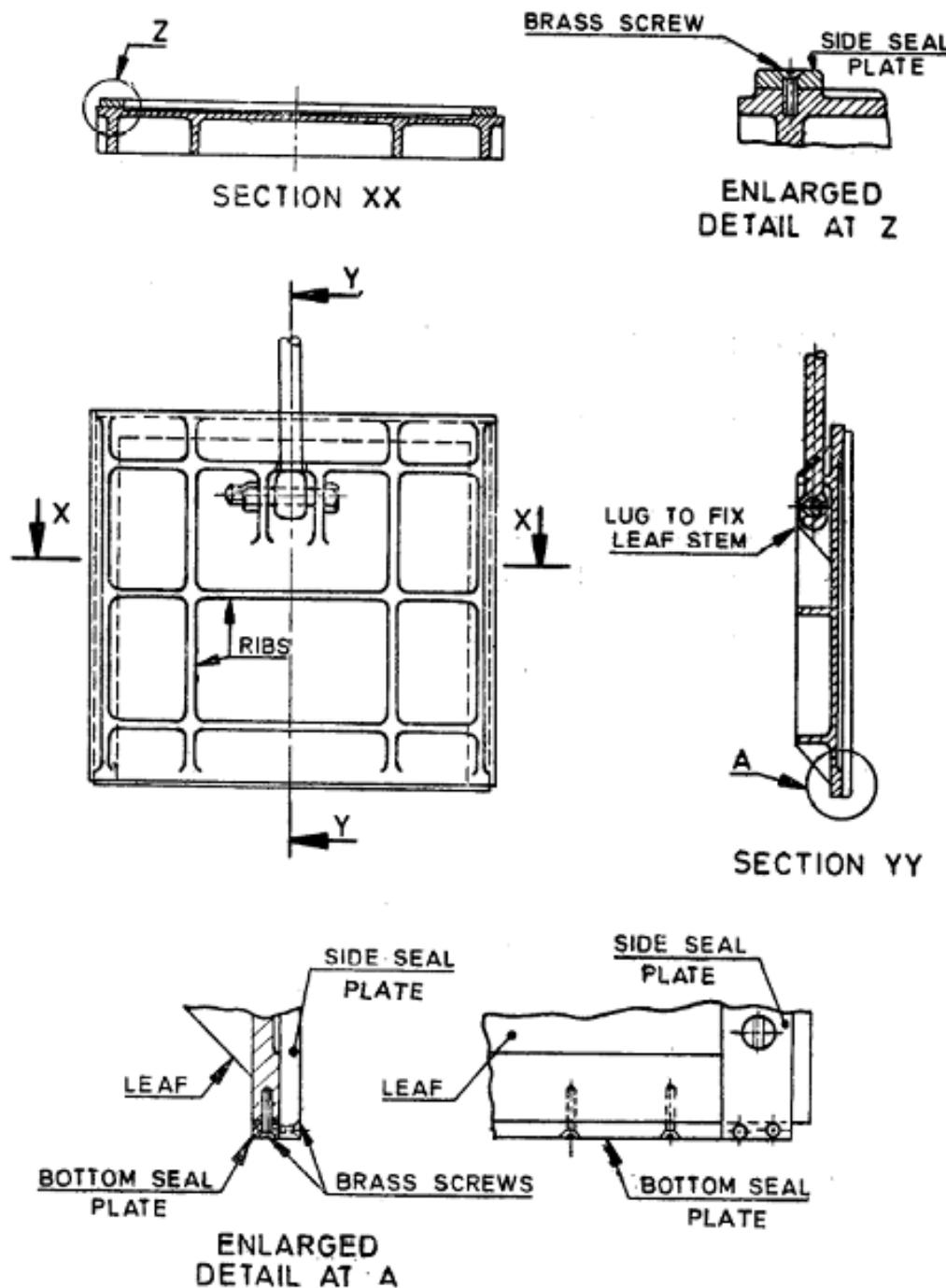


FIG. 2 TYPICAL DIAGRAM SHOWING LOW HEAD SLIDE GATE LEAF

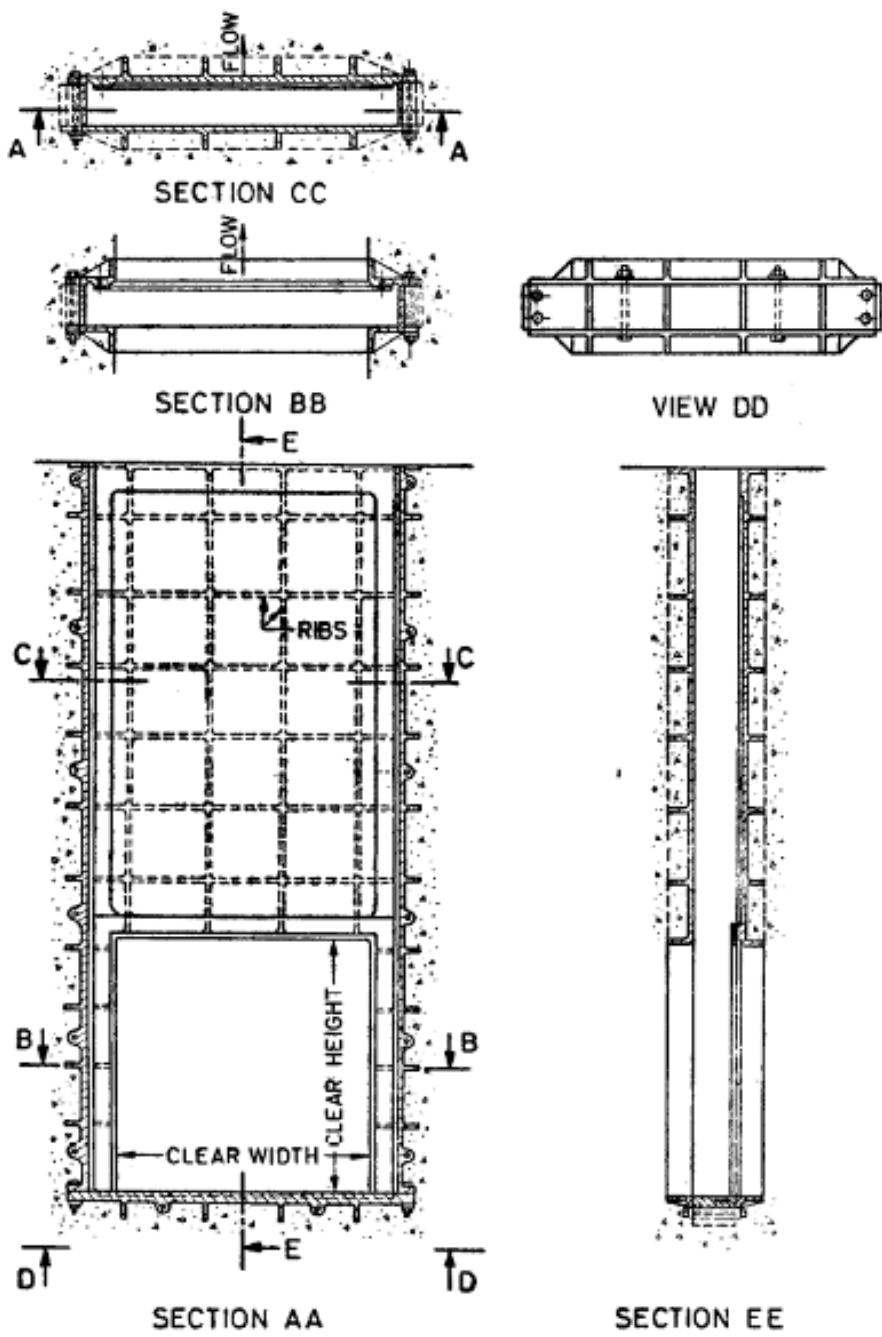
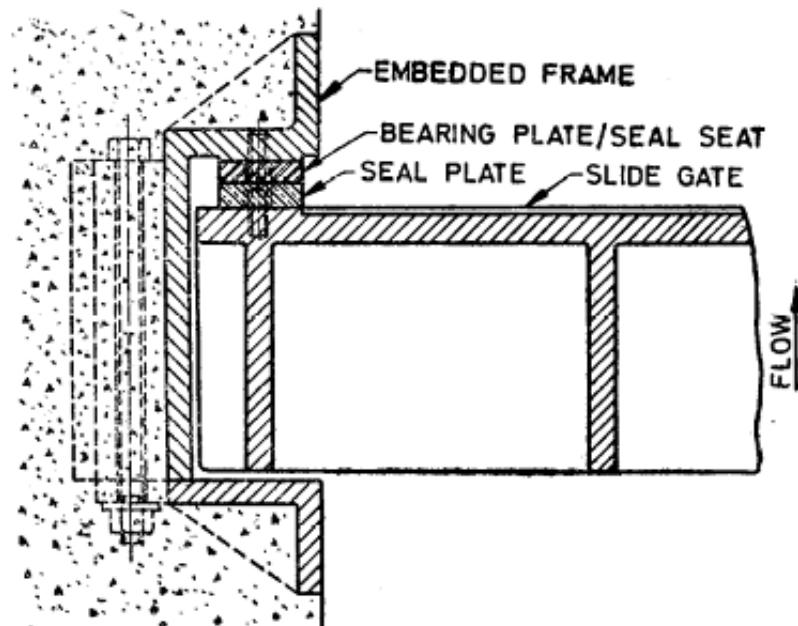
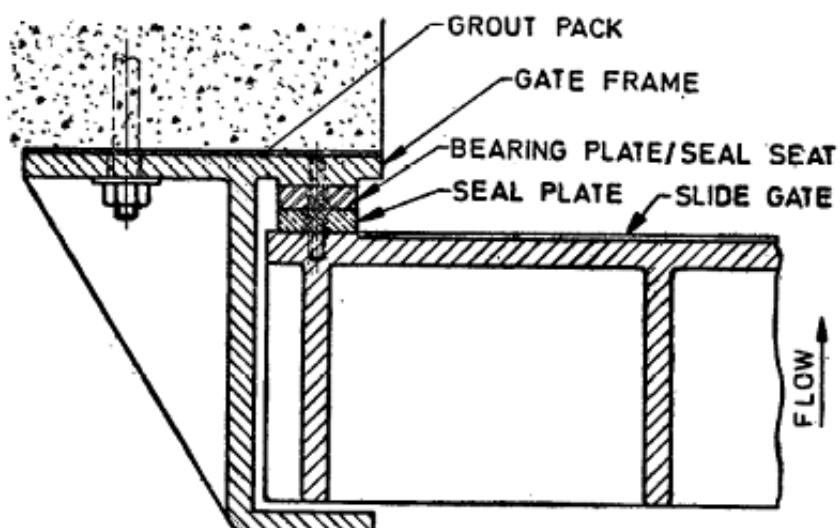


FIG. 3 TYPICAL DIAGRAM SHOWING EMBEDDED FRAME OF LOW HEAD SLIDE GATE

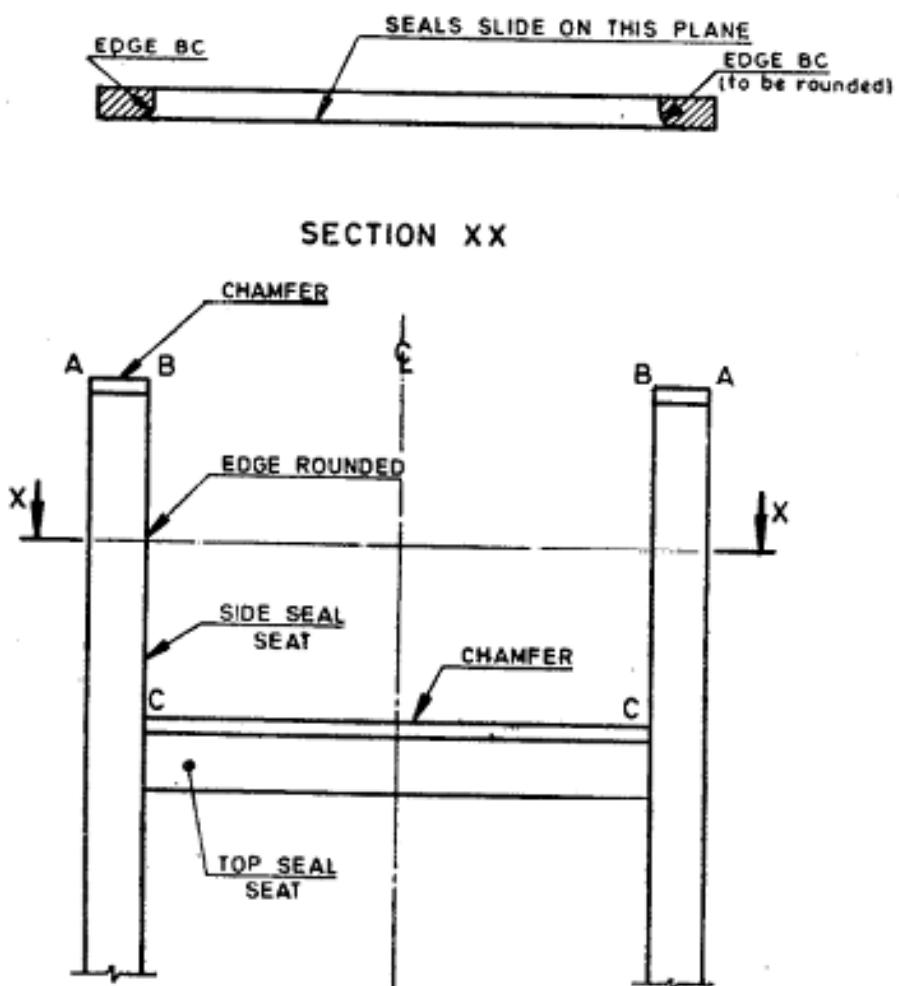


4A Typical Slot Section Detail Showing Low Head Slide Gate and Embedded Frame



4B Typical Slot Section Detail Showing Low Head Slide Gate and Full Face Gate Frame

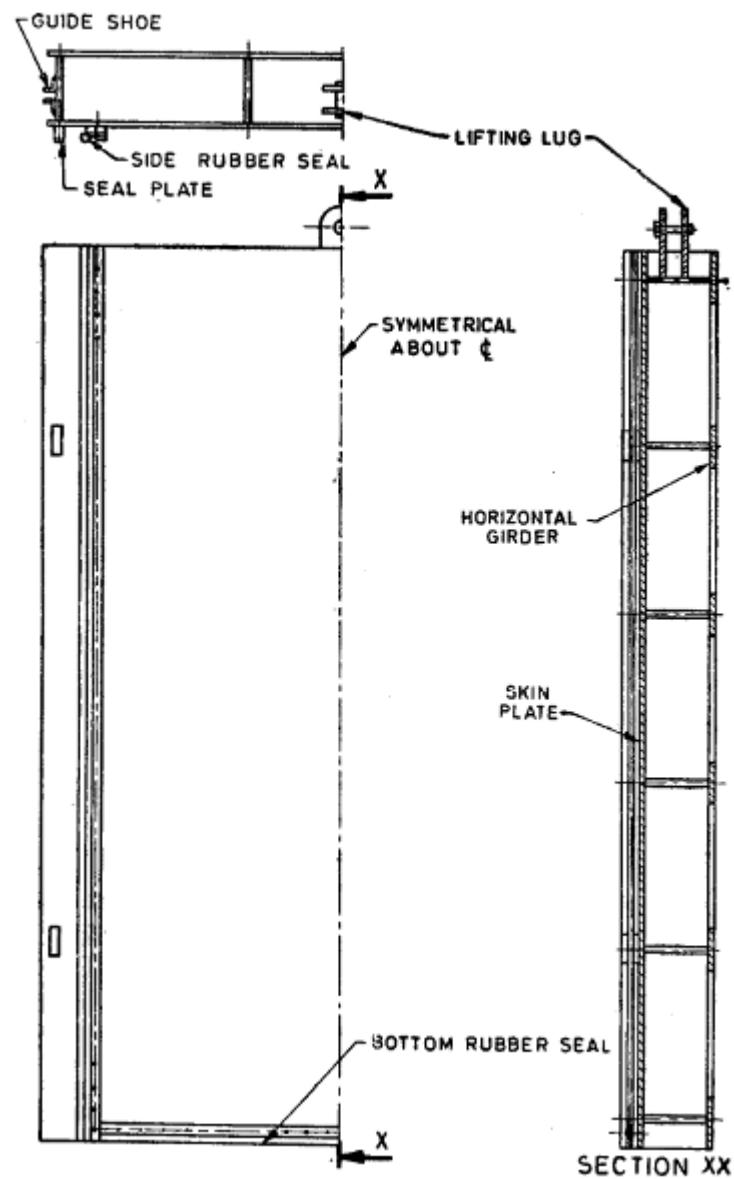
FIG. 4 LOW HEAD SLIDE GATE SHOWING GATE AND EMBEDDED FRAME



NOTE 1 — Edges *AB* and *CC* to be chamfered.

NOTE 2 — Edges *BC* to be rounded.

FIG. 5 ROUNDING/CHAMFERING OF SEAL SEAT

**6A Stoplog (With Rubber Seal)**FIG. 6 LOW HEAD SLIDE GATE SEALING ARRANGEMENT — (*Continued*)

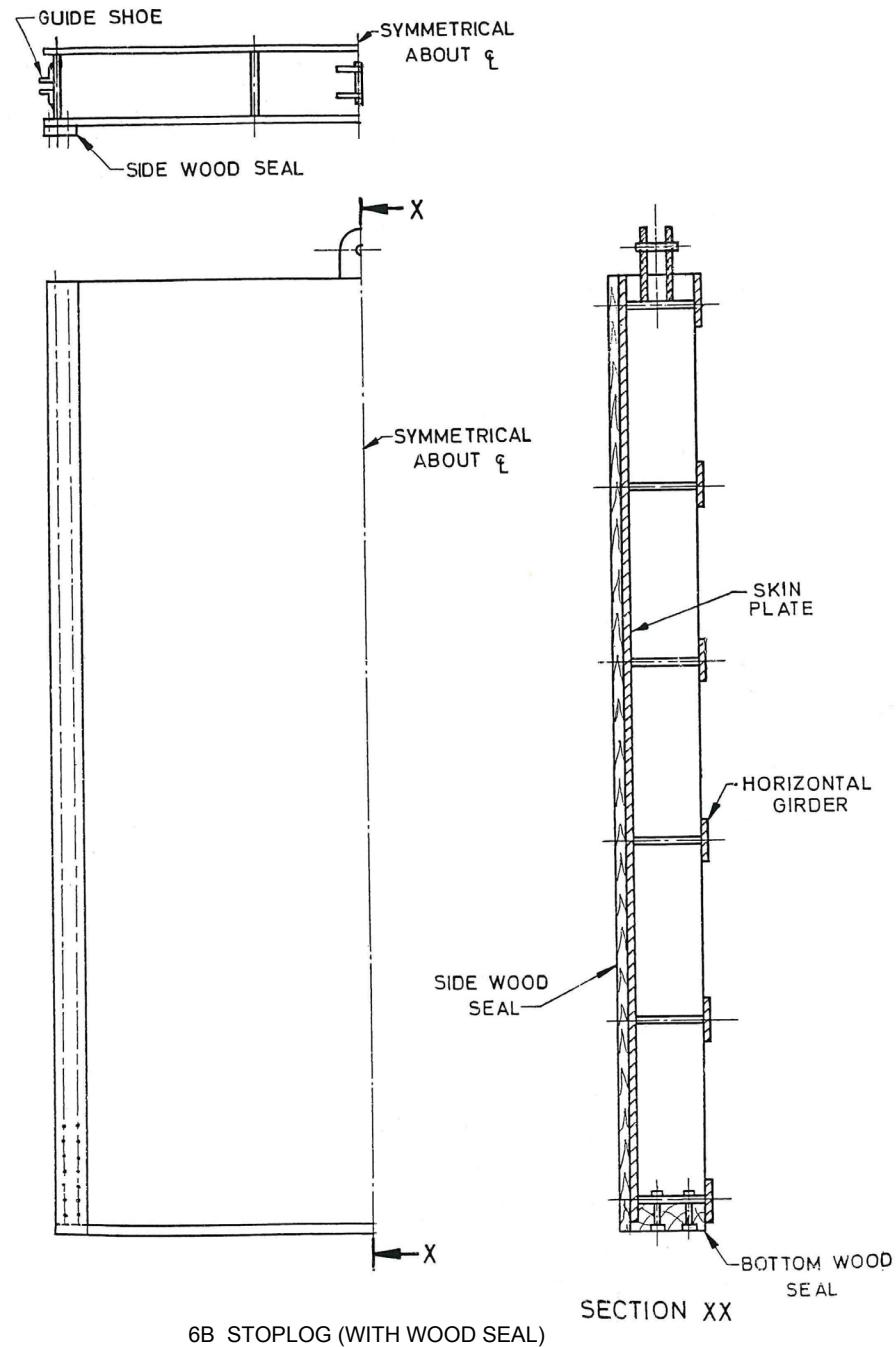
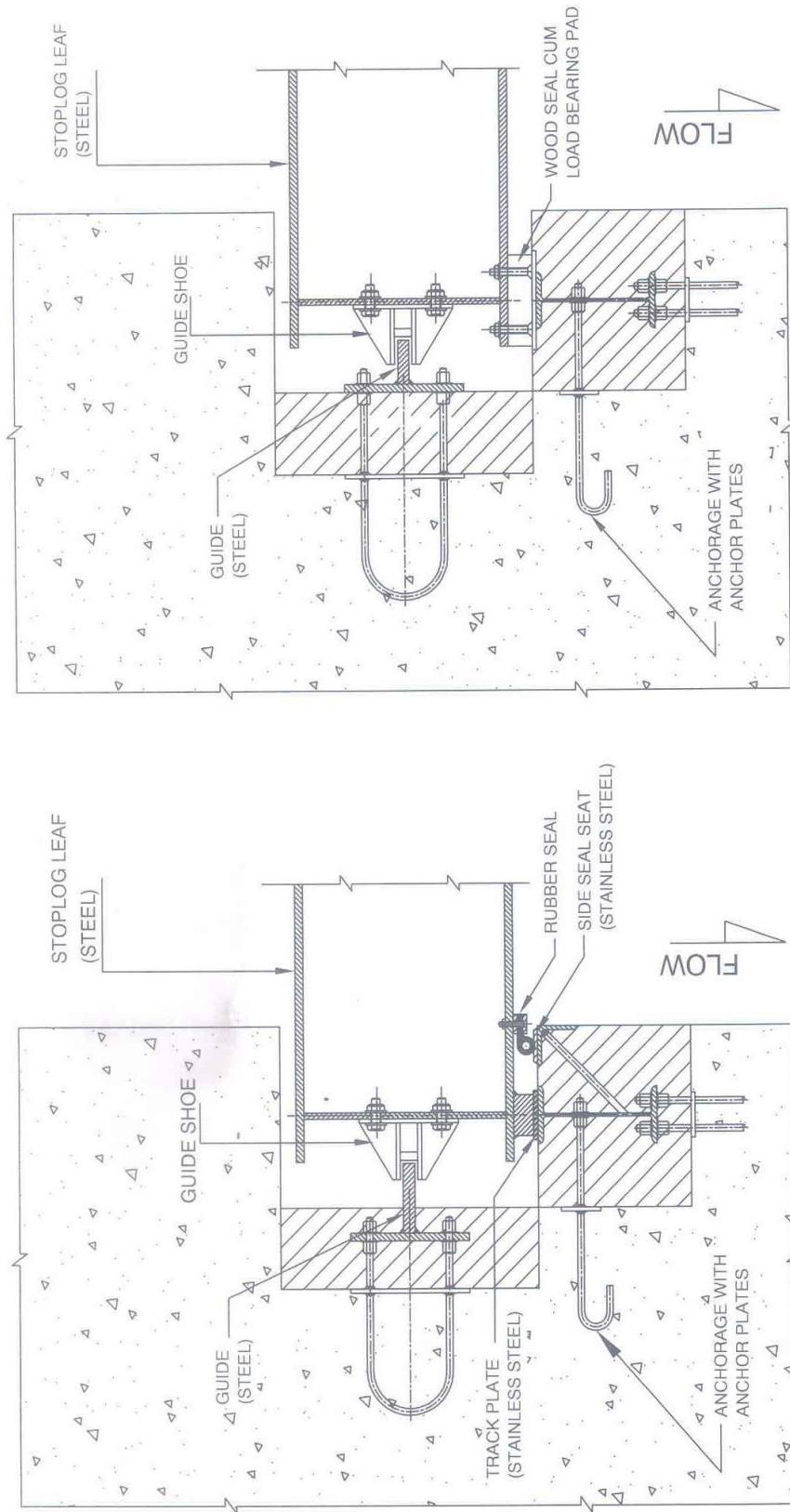


FIG. 6 LOW HEAD SLIDE GATE SEALING ARRANGEMENT — (*Continued*)



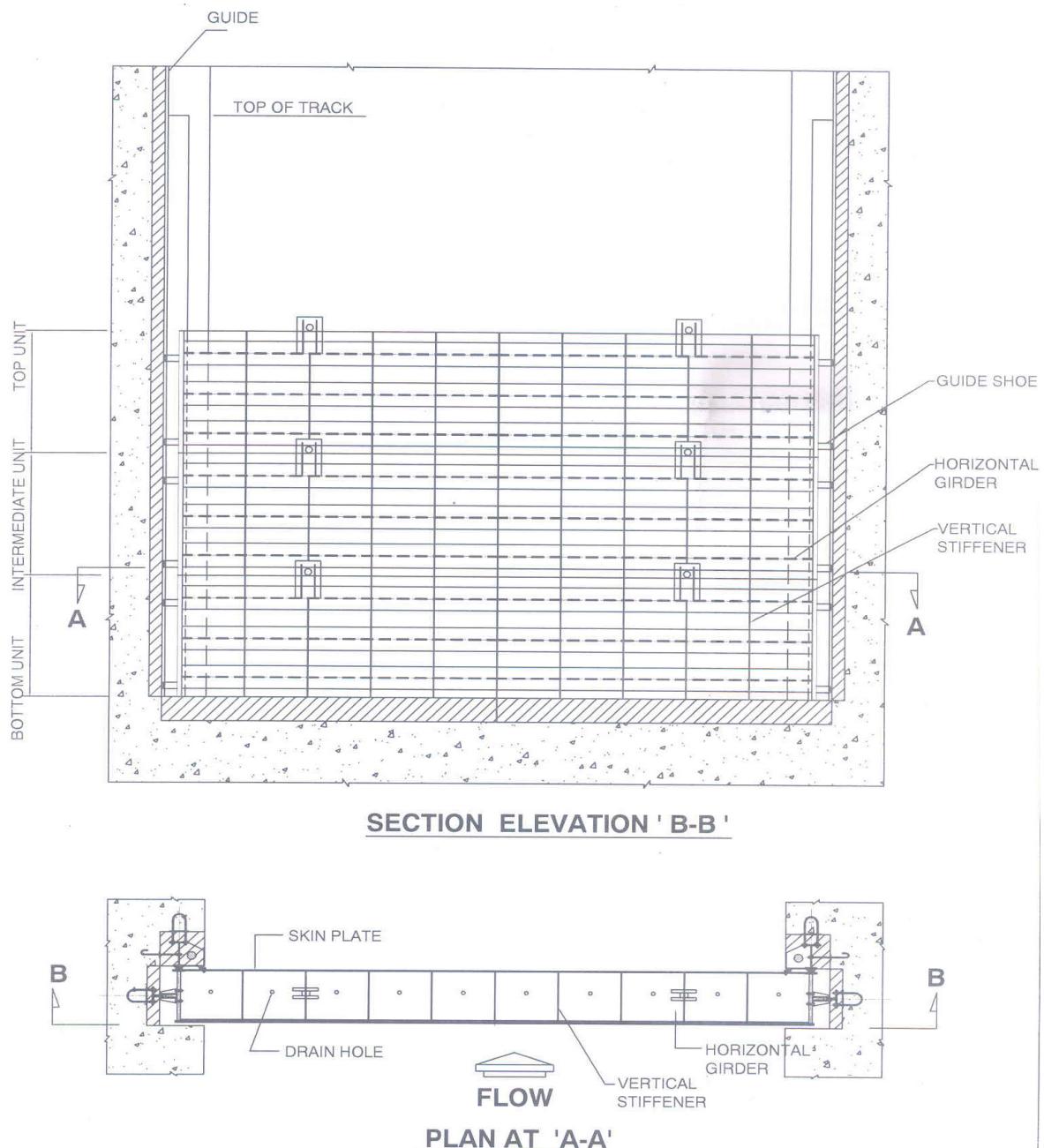


FIG. 7 GENERAL ARRANGEMENT OF LOW HEAD STOPLOGS IN MULTIPLE UNITS

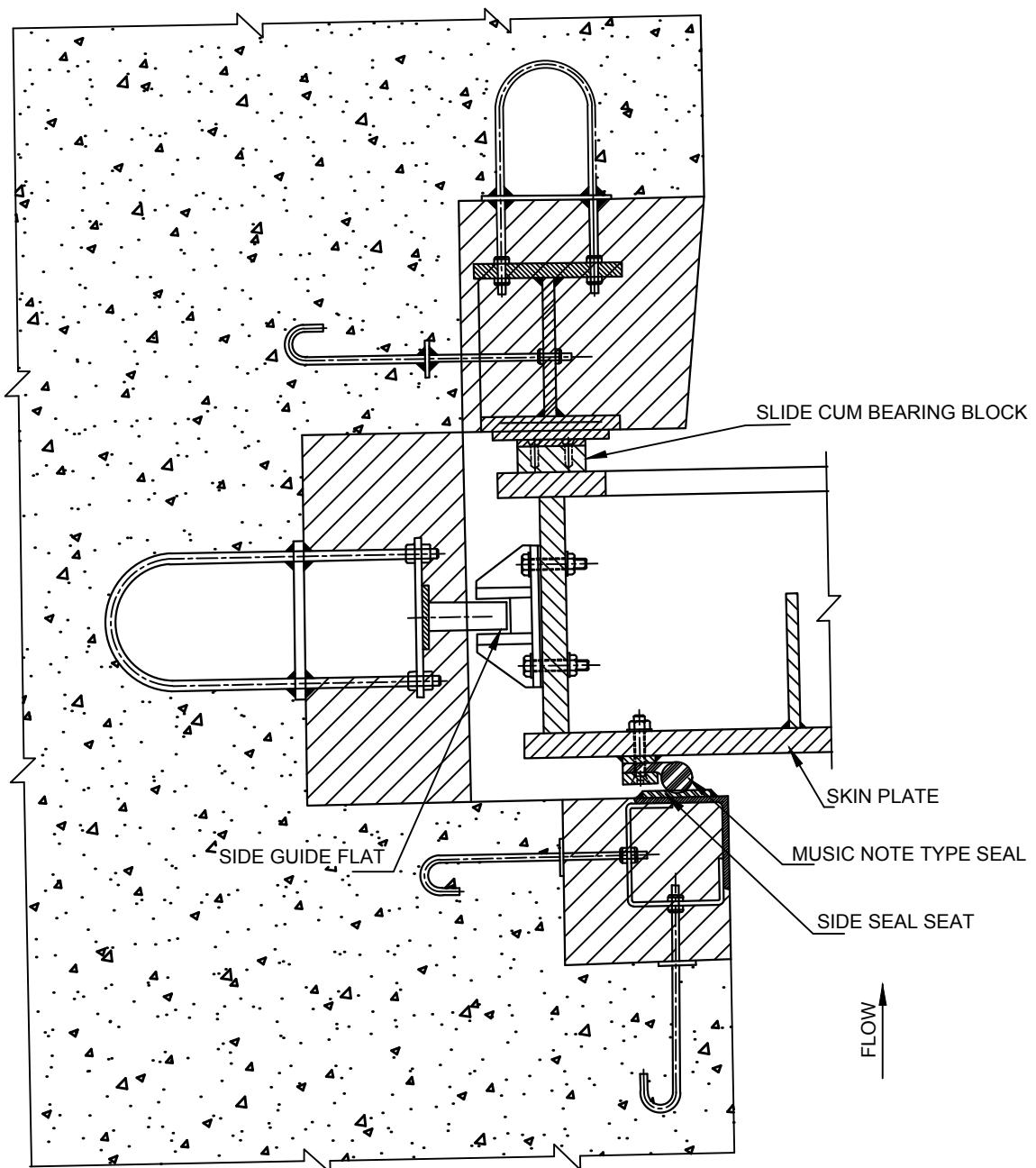


FIG. 8 LOW HEAD SLIDE GATE WITH UPSTREAM SEALING AND UPSTREAM SKIN PLATE

7 LOADING

7.1 The gate shall be designed for hydrostatic and the hydrodynamic forces taking into consideration forces arising from wave effects and ice formation, wherever applicable.

7.2 Earth quake forces shall be considered in accordance with IS 1893.

7.3 Silt load, if applicable, shall also be considered.

8 STRUCTURAL DESIGN

8.1 Gate leaf

8.1.1 The skin plate and stiffener shall be designed together in a composite manner.

8.1.2 The skin plate shall be designed for the following two conditions unless more precise methods are available:

- In bending across the stiffeners or horizontal girders; as applicable, or
- As panels in accordance with the procedure and support conditions as given in Annex D.

8.1.3 The stresses in skin plates for conditions in **8.1.2** shall be determined as follows:

- For determining the stresses for conditions in bending across stiffener or girders as per procedure in **8.1.2** (a), bending moment shall be determined according to the conditions of support.
- For calculating the stresses in skin plates for condition in bending as panel in accordance with the procedure given in **8.1.2** (b), the stresses as given in Annex D shall be used.

8.1.4 In either of cases specified in **8.1.2** while designing the stiffener and horizontal girders, the skin plate can be considered coacting with them.

- The coacting width of the skin plate in non panel fabrication as per **8.1.2** (a) that is, when skin plates coacts only with horizontal girders or vertical / horizontal stiffeners shall be taken as least of the following values:

- $40t + B$;

where,

t = thickness of skin plate; and

B = width of stiffener flange in contact with the skin plate.

- 0.11 span; and

- Center-to-center of stiffeners or girders

- When skin plate coacts with horizontal girders as well as vertical stiffeners that is, acts as an orthotropic plate, to form a panel construction,

width of skin plate coacting with horizontal girder or stiffener shall be worked out as illustrated in Annex E.

8.1.5 The stresses so computed shall be combined in accordance with formula:

$$\sigma_v = \sqrt{(\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2)}$$

where,

σ_v = combined stress;

σ_x = sum of stresses along x axis;

σ_y = sum of stresses along y axis; and

τ_{xy} = sum of shear stresses along x-y plane.

NOTE — The appropriate algebraic signs should be taken for σ_x and σ_y in the above formula.

8.1.6 The permissible value of mono-axial as well as combined stresses should not be greater than those specified in Annex C.

8.1.7 Permissible value of stresses in the welds shall be the same as permitted for the parent material. For site weld efficiency should be considered 80 percent of shop weld.

8.1.8 To take care of corrosion, the actual thickness of skin plate to be provided shall be at least 1.5mm more than the theoretical thickness computed based on the stresses in Annex C. The minimum thickness of skin plate shall not be less than 8 mm exclusive of corrosion allowance.

8.1.9 Horizontal and Vertical Stiffeners/Girders

8.1.9.1 The horizontal and vertical stiffeners shall be designed as simply supported or continuous beams depending upon the framing adopted for gate. The spacing between main horizontal girders shall preferably be such that all the girders carry almost equal loads. The stiffeners may, if necessary, be of a built up section or of standard rolled section, that is, tees, angles, channels etc.

8.1.9.2 The span of the horizontal girders shall be taken between centers of end vertical girders. The end vertical girder shall be designed as continuous beam having concentrated loads coming from horizontal girders at points where they meet the end vertical girders and uniform reaction from the bearing plate.

8.1.10 Deflection of Gates

Maximum deflection of the gate/stoplogs/bulkhead under normal load should be limited to 1/800 of the span. However in case of gates with upstream top seal, a maximum deflection of the gate leaf at the top seal should not be more than 80 percent of the initial interference of the seal.

8.1.11 Aeration Requirement

The location and sizing of air vent is critical for minimizing cavitation and vibration problems associated with regulating gates. Such installation should be provided with adequate air supply downstream of the gate. For determination of air requirements and size of air vent IS 12804, should be referred.

8.2 Embedded Parts

8.2.1 Embedded parts shall be rigid and adequately anchored in the concrete/masonry.

8.2.2 The section of the embedded parts shall be so chosen that bearing pressure on concrete/masonry shall not exceed the permissible values as specified in IS 456 and IS 1905 respectively. Second stage concrete shall be of one grade higher than the first stage concrete. The section of the track should be checked for bending and shear stress.

8.2.3 The embedded parts shall be embedded in concrete/masonry as a second stage and suitable anchors shall be provided to align the embedded parts within tolerance of 3 mm. In case embedded parts are embedded in first stage concrete /masonry, it should be ensured that they are aligned properly.

8.3 Seals

8.3.1 The seal shall be fixed to the gate leaf by means of countersunk screws made of stainless steel. The hole in the seal shall be counter bored to accommodate the conical head of the screws. When assembled, the heads of the screws shall remain 1.0 mm below the surface of the seal. The screws used for fixing of seals to the gate leaf shall be designed to take up full shear likely to develop between the seal and the gate leaf due to friction force encountered between the seal and seal seat during raising or lowering of gates under maximum head of water. The screws shall be adequately tightened to a constant torque and locked by punch marks. A compressed asbestos/rubber gasket may be provided between the gate leaf and seal-cum-bearing pad to prevent leakage. Shear plugs may be provided in addition, at the discretion of the designer. The bottom seal may be of wedge type and manufactured from rubber. For reducing the friction, fluorocarbon cladded seals may be used.

8.3.2 The surface of the gate leaf over which seals are fixed, shall be machined and the surface finish of the sliding surface of slide/bearing cum sealing block shall be as per IS 3073.

8.3.3 Minimum threaded length equivalent to one and half times the diameter of the screws shall be screwed in the gate leaf to ensure against their loosening under vibrations during operations.

8.3.4 Suitable chamfer shall be provided at the bottom of the gate leaf/clamp plate to accommodate the bottom wedge seal in compressed position.

8.3.5 For regulating gates, the designer at his discretion may make the seals effective throughout the range of travel of gates either by fixing the seal to the embedded parts or by providing a liner plate above in continuation of the top seals for the entire width of the gate and range of regulation.

8.3.6 The following types of seals are generally employed for low head slide gates:

- a) Wood,
- b) Rubber, or
- c) Metal.

8.3.6.1 Wood seals

Entire water load on the gate element is transferred to the embedded parts through the seal. The woods commonly used for seals are sal, deodar and shisham. The seals should be used in such a way that compression is parallel to the grain. The maximum permissible compressive stress to be adopted in design of seals may be taken as given below:

- a) For hard woods (teak and shisham) 240 N/cm², or
- b) For deodar and sal wood 140 N/cm².

8.3.6.1.1 The wood seals shall be fixed by means of socket head shoulder bolts and seals shall be counter-bored to accommodate the heads of the bolts which shall remain at least 3 mm below the surface of the seal.

8.3.6.1.2 The bottom seal shall project at least 15 mm below the gate leaf and shall be designed to support the full weight of the gate leaf.

8.3.6.2 Rubber seals

The rubber seals for sides and top shall be of music note type and shall be fixed to the gate leaf by seal clamps and stainless steel bolts/ screws. The edge of seal clamp adjacent to the seal bulb shall be rounded. The rubber seal for the bottom may be wedge type and shall project 5mm below the gate leaf.

8.3.6.3 Metal seal plates

The metal seal plates should be of either brass or bronze or stainless steel and should be fixed to the gate leaf by countersunk screws made of stainless steel or of the same material. These should also transmit the entire water load on the gate leaf to the embedded parts and the width of the sealing strips should be sufficient so as to keep the maximum bearing stress within the prescribed limits. The deviation in the alignment of metal seal plate and bearing plate should not exceed + 1.0 mm.

8.4 Bearing Plates/Seal Seats and Sill

8.4.1 For the seal seats/bearing plates and sill of slide gates, one of the following materials may be used :

- a) Cast iron,
- b) Structural steel,
- c) Brass,
- d) Bronze, or
- e) Stainless steel.

8.4.2 Where metal seal plates and bearing plates are provided, materials having the same chemical composition shall not be used for them. The material for seal plates fixed to gate leaf shall be somewhat softer than material for bearing plate so that wearing is on seal plates and not on bearing plates and also tendency of seizing is avoided under load.

8.4.3 The bearing plates, when of brass, bronze or gun metal, shall be fixed to the base by means of countersunk screws/bolts made of stainless steel or of the same material as of the bearing plates. The holes in the bearing plates shall be suitably counter bored and, when assembled, the heads of the screws/bolts shall remain one millimeter below the surface of the bearing plate.

8.4.4 Bearing plates of structural steel and stainless steel (corrosion resisting) may be welded to the embedded parts. Bearing plates of cast iron are generally used when embedded parts are also of cast iron. In such cases, these are cast integrally with the embedded parts.

8.4.5 Where the water load is transferred to the embedded parts by end diaphragms and rubber seals are used, surface of the frame may itself serve as the bearing plate and no separate bearing plate may be provided.

8.4.6 The sill beam may be manufactured from bronze, brass or gun metal flats, if required, and fixed with screws made of stainless steel or of the material as that of bottom seal seat. The seal seats of stainless steel may be welded.

8.4.7 The sealing surface of sill beam flats, bearing plates/ seal seats shall be in one plane and smooth. The sealing surface of sill beam flats shall be flushed with surrounding concrete, unless otherwise specified.

8.4.8 The edges of seal seat should be rounded/ chamfered as indicated in Fig. 5 to prevent damage to rubber seal during gate operation.

8.4.9 Typical details of rubber seals or wood seals used in low head slide gates are shown in Fig. 6.

8.4.10 The surface finish of seal seats shall not be less than double delta (*see IS 3073*).

8.5 Guides

8.5.1 Suitable guide shall also be provided on the embedded parts to limit its lateral and longitudinal movements of the gate/stoplogs within a tolerance of 3 mm in every 3 m height with overall tolerance of 5 mm.

8.6 Tolerances

The tolerances for embedded parts and in components of gate shall be as given in Annex F.

8.7 Clearances

Where the frame serves as a guide, the clearance should be as follows:

- a) Longitudinal (along the flow) clearance between the leaf and frame: 3 to 5 mm
- b) Transverse (perpendicular to the flow) clearance between leaf and frame: 5 to 8 mm

8.8 Connection for the Hoist

Provision shall be made for stem of hoist to be fixed on the gate leaf. The stem connection may be hinged as to allow for inaccuracies in stem alignment. In case of stoplogs, suitable arrangement for engaging the crane hook on the top of stoplogs should be provided. The location of the hook shall be such that the gate or stoplogs, when hung, shall remain truly vertical.

8.9 Values of Coefficient of Friction

Values of coefficient of friction recommended for the design of gates are given in Annex G.

9 OCCASIONAL FORCES

9.1 Wave Effect

For very wide and big reservoirs, the effect of wave height due to storms in causing increased loading on the gate shall be in accordance with IS 10635.

9.2 Earth Quake Effect

Earth quake forces shall be computed in accordance with provisions of IS 1893.

9.3 The stresses in various parts of the gate under the action of occasional forces shall not exceed 133 percent of the permissible stresses specified in Annex C subject to the maximum of 85 percent of the yield stress. In case of nuts and bolts, increase in stress shall not be more than 25 percent of allowable stress.

9.4 The earthquake forces and the wave effect shall not be considered to act simultaneously while computing the increased stress in the gate.

9.5 Gates should not be allowed for over topping. However in case of occasional over topping the design should be checked for 133 percent of normal stress.

10 ICE LOADS

10.1 Ice Impact and Ice Pressure

Provided local conditions do not impose other values, ice impact and ice pressure shall be taken into account in such a way that the water pressure triangle shall be replaced as given below:

- a) In water with ice thickness greater than 30 cm, by an even surface pressure of 30 000 N/m² up to 3 m depth, and
- b) In waters with ice thickness up to 30 cm, by an even surface pressure of 20 000 N/m² up to 2 m depth.

11 MWL CONDITION

In case the gate is to be checked for MWL condition, the allowable stress shall be increased by $33\frac{1}{3}$ percent of the values specified in Annex C subject to the 85 percent of upper limit of yield point. However, if the gates are required to be designed for MWL condition, normal stresses shall be taken in accordance with Annex C.

ANNEX A

(Clause 2)

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
210 : 2009	Grey iron castings — Specification (<i>fifth revision</i>)	1905 : 1987	Code of practice for structural use of unreinforced masonry (<i>third revision</i>)
291 : 1989	Naval brass rods and sections for machining purposes — Specification (<i>third revision</i>)	2004 : 1991	Carbon steel forgings for general engineering purposes — Specification (<i>third revision</i>)
305 : 1981	Aluminium bronze ingots and castings (<i>second revision</i>)	2062 : 2011	Hot rolled low, medium and high tensile structural steel (<i>seventh revision</i>)
306 : 1983	Specification for tin bronze ingots and castings (<i>third revision</i>)	3073 : 1967	Assessment of surface roughness
318 : 1981	Specification for leaded tin bronze ingots and castings (<i>second revision</i>)	6603 : 2001	Stainless steel bars and flats — Specification (<i>first revision</i>)
456 : 2000	Plain and reinforced concrete — Code of practice (<i>fourth revision</i>)	6911 : 2017	Stainless steel plate, sheet and strip (<i>second revision</i>)
800 : 2007	General construction in steel — Code of practice (<i>third revision</i>)	10635 : 2014	Freeboard requirements in embankment dams — Guidelines (<i>second revision</i>)
1030 : 1998	Carbon steel castings for general engineering purposes — Specification (<i>fifth revision</i>)	11855 : 2017	Guidelines for design and use of different types of rubber seals for hydraulic gates (<i>second revision</i>)
1458 : 1965	Specification for railway bronze ingots and castings (<i>first revision</i>)	12804 : 1989	Criteria for estimation of aeration demand for spillway and outlet structure
1893 : 1984	Criteria for earthquake resistant design of structures (<i>fourth revision</i>)		

ANNEX B

(Clause 3)

RECOMMENDED MATERIALS FOR VARIOUS COMPONENTS**B-1 DETAILS OF MATERIALS**

B-1.1 The recommended materials for various components are given below:

a) Gate Leaf

Cast Iron	IS 210
Structural steel	IS 2062
Cast steel	IS 1030

b) Gate Frames

Cast Iron	IS 210
Structural steel	IS 2062

c) Seal Plates/ Seals

Bronze	IS 306
	IS 318
	IS 1458
	IS 305
Brass	IS 291
Steel	IS 2062
Cast iron	IS 210
Stainless steel or stainless steel clad plate	IS 6911
Wood	Commercial good quality
Rubber	IS 11855

d) Seal Seats/Bearing Plates

Bronze	IS 306
	IS 318
	IS 1458
Brass	IS 291
Steel	IS 2062
Cast iron	IS 210
Stainless steel or stainless steel clad plate	IS 6911

e) Guides

Structural steel	IS 2062
Corrosion resisting steel	IS 6603
f) Guide shoes/rollers	
Structural steel	IS 2062
Cast iron	IS 210
Cast steel	IS 1030
Forged steel	IS 2004

NOTES — Cladding shall be done by established metallurgical methods in manufacturers' mill and not by plug welding.

ANNEX C

(Clause 6.1, 8.1.6 and 8.1.8)

**PERMISSIBLE MONOAXIAL STRESSES FOR STRUCTURAL
COMPONENTS OF HYDRAULIC GATES**

Sl No.	Material and Types of Stress		Wet Condition		Dry Condition	
	(1)	(2)	Accessible	Inaccessible	Accessible	Inaccessible
		(3)	(4)	(5)	(6)	
i) Steel:						
a)	Direct compression and compression in bending	0.45 YP	0.40 YP	0.55 YP	0.45 YP	
b)	Direct tension and tension in bending	0.45 YP	0.40 YP	0.55 YP	0.45 YP	
c)	Shear Stress	0.35 YP	0.30 YP	0.40 YP	0.35 YP	
d)	Combined stress	0.60 YP	0.50 YP	0.75 YP	0.60 YP	
e)	Bearing stress	0.65 YP	0.45 YP	0.75 YP	0.65 YP	
ii) Bronze or Brass						
	Bearing Stress	0.035 UTS	0.030UTS	0.040 UTS	0.035 UTS	

NOTES

1 YP stands for minimum guaranteed yield point stress, UTS stands for ultimate tensile strength. For materials which have no definite yield point, the yield point may be taken at 0.2 percent proof stress.

2 When the members are subjected to direct compression/compression in bending the l/r ratio of members is to be considered in accordance with the IS 800 and the permissible compressive stresses correspondingly reduced in proportion given in Annex C.

3 The term 'wet condition' applies to skin plates and those components of gate which may have a sustained contact with water, for example, horizontal girder and other components located on upstream side of skin plate. The term 'dry condition' applies to all components which generally do not have a sustained contact with water, for example, girders, stiffeners, etc, on downstream side of skin plate, even though there may be likelihood of their wetting due to occasional spray of water. Stoplogs are stored above water level and are only occasionally used. Hence stresses given under 'dry and accessible' condition should be applied to them.

4 The term 'accessible' applies to gates which are kept in easily accessible locations and can, therefore, be frequently inspected and maintained, for example, gates and stoplogs which are stored above water level and are lowered only during operations. The term 'inaccessible' applies to gates which are kept below water level and/or are not easily available for frequent inspection and maintenance, for example, gates kept below water level or in the bonnet space even while in the raised position or gates which on account of their frequent use are generally in water.

5 In gate leaves made of cast iron, the maximum permissible tensile strength should be limited to 10 percent of ultimate tensile strength.

ANNEX D

[Clause 8.1.2(b)]

METHOD OF COMPUTATION OF BENDING STRESSES
IN FLAT PLATES

D-1 STRESSES OF FLAT PLATES IN PANELS

Bending stresses in flat plates may be computed from the following formula:

$$\sigma = \frac{k}{100} \cdot \frac{pa^2}{S^2} \text{ N/cm}^2$$

where,

 σ = bending stress, in flat plate in N/cm^2 ; k = non-dimensional factor; p = water pressure, in N/cm^2 (relative to the plate center); a, b = bay width, in cm as in Fig. 9 to 14; and S = plate thickness, in cm.

The values of k for the points and support conditions shown in Fig. 9 to 14 are given in Table 1, 2 and 3.

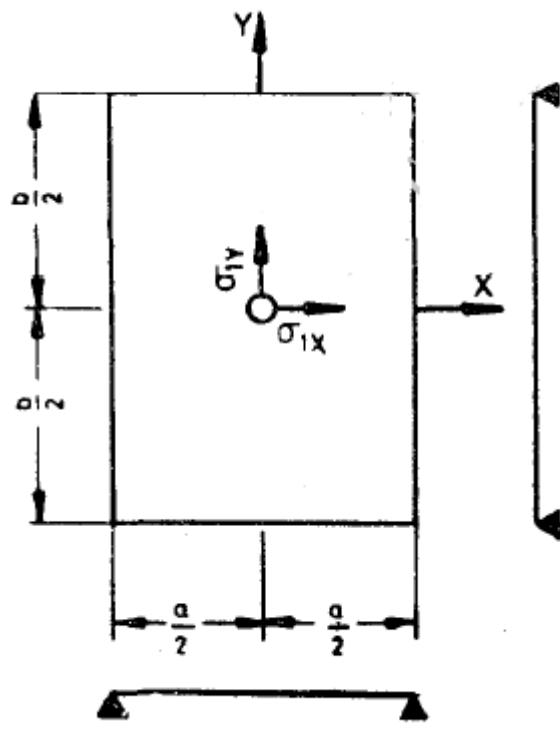


FIG. 9 ALL EDGES SIMPLY SUPPORTED

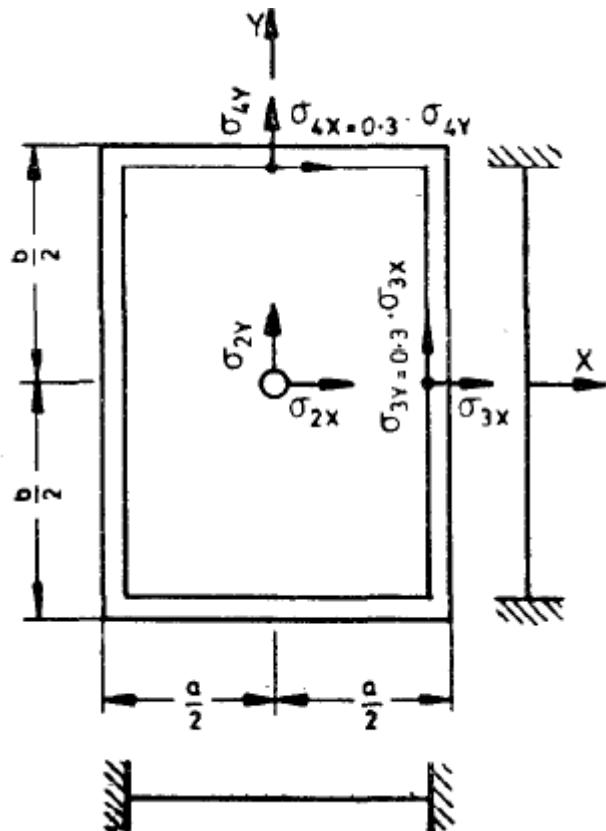


FIG. 10 ALL EDGES RIGIDLY FIXED

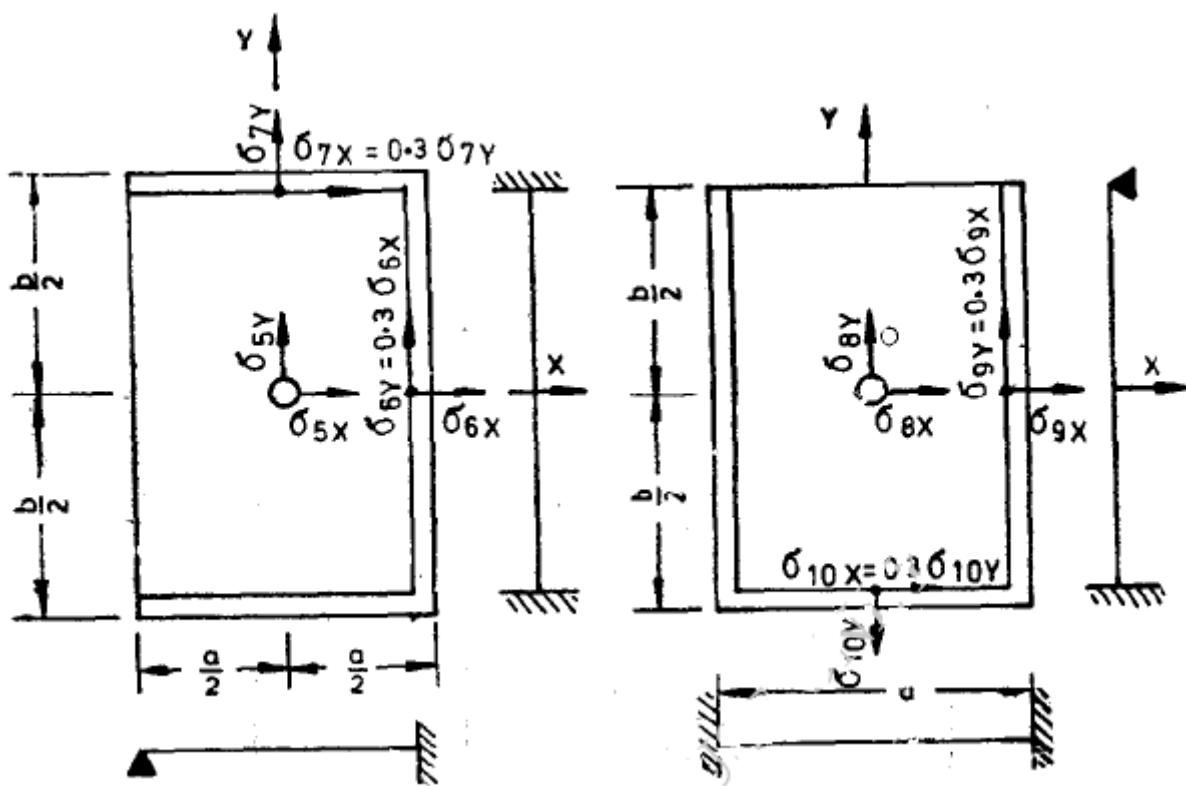


FIG. 11 TWO SHORT AND ONE LONG EDGES FIXED AND
ONE LONG EDGE SIMPLY SUPPORTED

FIG. 12 TWO LONG AND ONE SHORT EDGES FIXED AND
ONE SHORT EDGE SIMPLY SUPPORTED

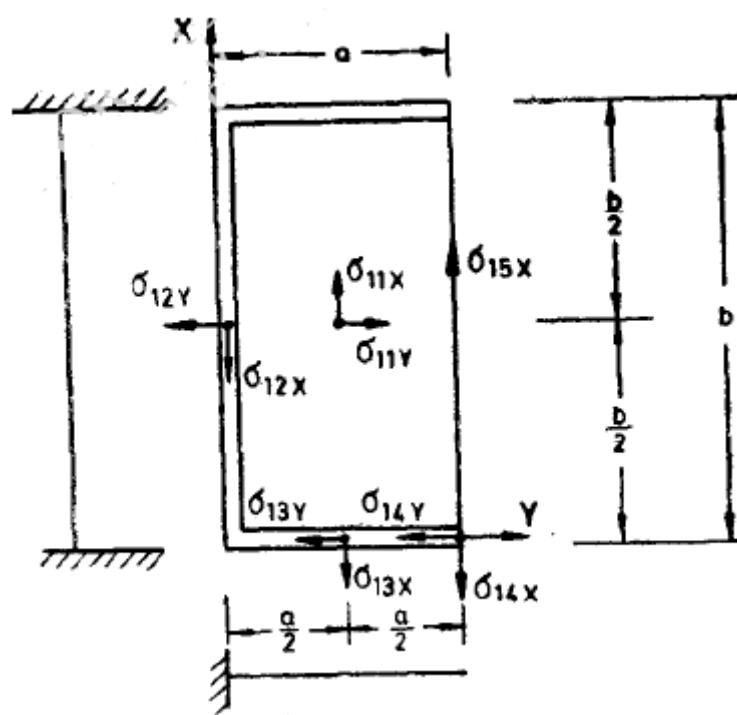


FIG. 13 THREE EDGES FIXED AND ONE (LONGER) EDGE FREE

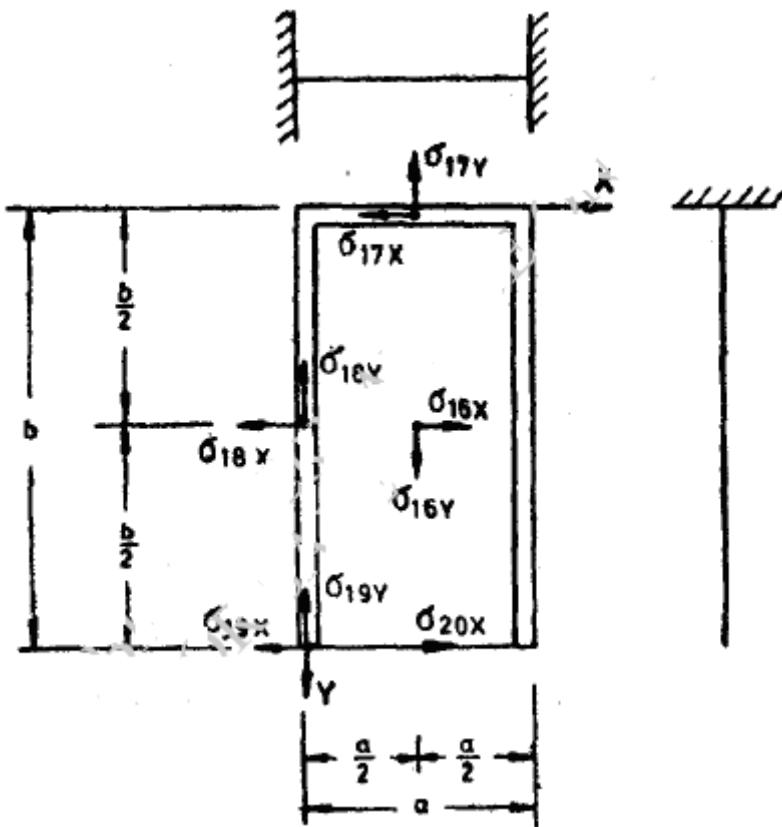


FIG. 14 THREE EDGES FIXED AND ONE (SHORTER) EDGE FREE

Table 1 Values of k for Points and Support Conditions Shown in Fig. 9 To 12
(Clause D-1.1)

b/a	$\pm\sigma_{1x}$	$\pm\sigma_{1y}$	$\pm\sigma_{2x}$	$\pm\sigma_{2y}$	$\pm\sigma_{4y}$	$\pm\sigma_{3x}$	$\pm\sigma_{5x}$	$\pm\sigma_{5y}$	$\pm\sigma_{7y}$	$\pm\sigma_{6x}$	$\pm\sigma_{8x}$	$\pm\sigma_{8y}$	$\pm\sigma_{10y}$	$\pm\sigma_{9x}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
α	75.0	22.5	25.0	7.5	34.2	50.0	37.5	11.3	47.2	75.0	25.0	7.5	34.2	50.0
3	71.3	24.4	25.0	7.5	34.3	50.0	37.4	12.0	47.1	74.0	25.0	7.6	34.2	50.0
2.5	67.7	25.8	25.0	8.0	34.3	50.0	36.6	13.3	47.0	73.2	25.0	8.0	34.2	50.0
2	61.0	27.8	24.7	9.5	34.3	49.9	33.8	15.5	47.0	68.3	25.0	9.0	34.2	50.0
1.75	55.8	28.9	23.9	10.8	34.3	48.4	30.8	16.5	46.5	63.2	24.6	10.1	34.1	48.9
1.5	48.7	29.9	22.1	12.2	34.3	45.5	27.1	18.1	45.5	56.5	23.2	11.4	34.1	47.3
1.25	39.6	30.1	18.8	13.5	33.9	40.3	21.4	18.4	42.5	47.2	20.8	12.9	34.1	44.8
1	28.7	28.7	13.7	13.7	30.9	30.9	14.2	16.6	36.0	32.8	16.6	14.2	32.8	36.0

NOTE — The edges over which the panels are continuous may, for all practical purposes, be treated as edges rigidly fixed. However, more exact analysis may be resorted to at the discretion of the designer.

Table 2 Values of k for Points and Support Conditions Given in Fig. 13
(Clause D-1.1)

b/a	$\pm\sigma_{11x}$	$\pm\sigma_{11y}$	$\pm\sigma_{12x}$	$\pm\sigma_{12y}$	$\pm\sigma_{13x}$	$\pm\sigma_{13y}$	$\pm\sigma_{14x}$	$\pm\sigma_{14y}$	$\pm\sigma_{15x}$	$\pm\sigma_{15y}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
α	22.00	75.00	90.00	300.00	91.00	28.00	205.00	62.00	2.00	0
1.0	17.67	12.29	9.45	31.50	37.64	11.29	44.55	13.40	27.96	0
1.25	22.50	13.00	15.50	51.50	48.00	14.80	53.00	16.20	37.00	0
1.50	23.50	14.20	20.50	72.50	59.50	18.20	82.00	22.70	48.00	0
1.75	23.00	14.00	25.80	87.00	67.50	20.80	112.00	34.80	61.00	0
2.0	19.49	6.72	33.98	113.28	72.96	21.89	134.40	40.32	69.88	0
2.5	18.37	2.88	42.05	140.16	51.84	15.55	124.80	37.44	52.42	0
3.0	19.78	7.68	44.93	149.76	65.28	19.59	109.44	32.84	52.41	0

Table 3 Values of k for Points and Support Conditions Given in Fig. 14
(Clause D-1.1)

b/a	$\pm\sigma_{16x}$	$\pm\sigma_{16y}$	$\pm\sigma_{17x}$	$\pm\sigma_{17y}$	$\pm\sigma_{18x}$	$\pm\sigma_{18y}$	$\pm\sigma_{19x}$	$\pm\sigma_{19y}$	$\pm\sigma_{20x}$	$\pm\sigma_{20y}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
α	29.00	9.00	9.00	30.00	50.00	15.00	51.00	16.00	29.00	0
1.0	17.67	12.29	9.45	31.50	37.64	11.29	44.55	13.40	27.96	0
1.25	20.80	11.70	8.96	29.87	28.00	8.40	34.50	10.35	28.53	0
1.50	25.51	11.12	8.48	28.28	21.04	6.31	25.53	7.66	29.11	0
1.75	26.48	10.56	8.49	28.30	32.00	9.60	36.50	10.95	28.97	0
2.0	27.46	10.00	8.50	28.36	45.52	13.66	50.09	15.27	28.81	0
2.5	28.07	9.13	8.51	28.38	46.66	14.00	50.80	15.24	28.78	0
3.0	28.18	8.68	8.51	28.38	46.94	14.08	50.81	15.24	28.77	0

ANNEX E

(Clause 8.1.4)

**METHOD OF CALCULATION OF CO-ACTING WIDTH OF
SKIN PLATE FOR PANEL CONSTRUCTION**

E-1 METHOD**E-1.1 Method of Calculation of Co-acting**

Width of skin plate for panel construction is given by $2 VB$.

where,

V = reduction factor (non-dimensional) depends on the ratio of the support length to the span of the plate and on the action of the moments, and is ascertained from Fig. 15 and 16; and

B = half the span of the plate between two girders (see Fig. 15) or overhang length of a bracket plate.

E-1.1.1 The ideal support length (L_1 or L_{II} , see Fig. 15) corresponding to the length of the moment zone of equal sign shall in case of continuous girders be basis with regard to support length L .

In the case of single bay girders, the ideal support length corresponds to the actual.

V_I = reduction factor corresponding to the parabolic moment zone (see Fig. 15 and 16), and

V_{II} = reduction factor corresponding to the moment zone composed of two concave parabolic stresses and approximately the triangular shaped moment zone (shown with dashes in Fig. 15 and 16).

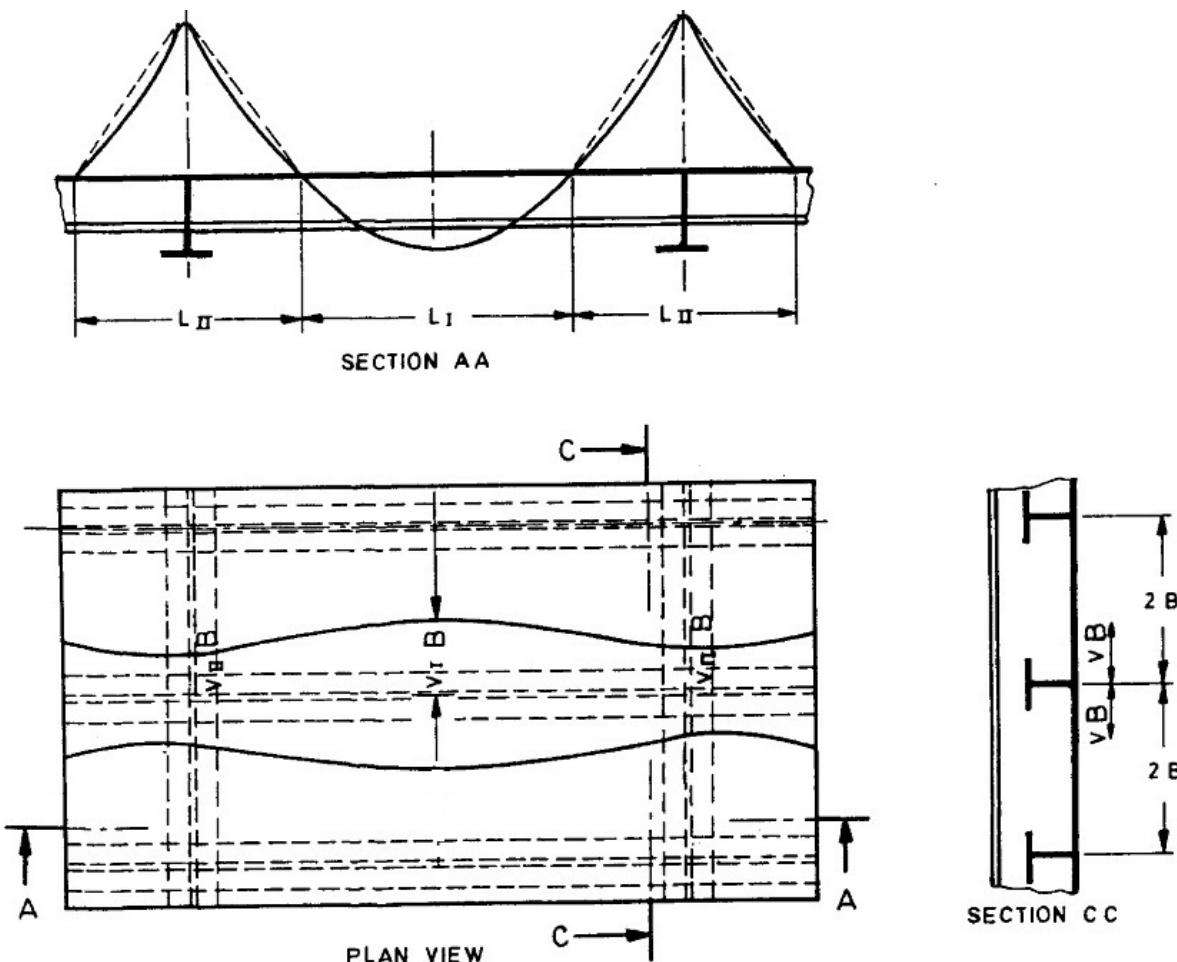


FIG. 15 FIGURE SHOWING VARIATION OF COACTING WIDTH FROM SUPPORT TO SUPPORT

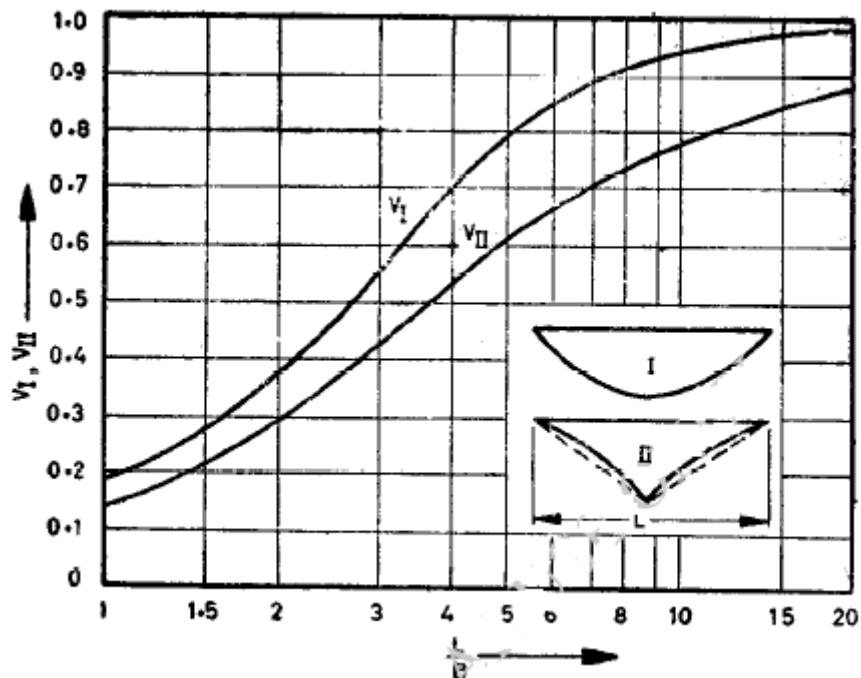


FIG.16 CURVES SHOWING RELATIONSHIP BETWEEN $\frac{L}{B}$ AND
REDUCTION FACTORS V_I AND V_{II}

ANNEX F

(Clause 8.6)

TOLERANCE FOR EMBEDDED PARTS AND COMPONENTS OF GATES

<i>Components</i>	<i>Tolerance (mm)</i>
I. EMBEDDED PARTS	
i) <i>Side Seal Seat :</i>	
a) Alignment in plane parallel to flow	± 0.50
b) Distance between center line of opening and seal seat	± 1.50
ii) <i>Top Seal Seat :</i>	
a) Alignment parallel to flow	± 0.50
b) Height above sill	± 1.50
c) Coplaneness with side seal seat	± 1.00
iii) <i>Side Guide Track:</i>	
a) Alignment in plane normal to flow	± 1.50
b) Distance between center line of opening and face of guide track	± 1.00
c) Alignment in plane parallel to flow	± 1.00
iv) <i>Critical Dimensions :</i>	
a) Centre-to-centre distance between side seal seat	± 3.00
b) Face-to-face distance between side guide tracks	± 2.00
c) Face of bearing plate to C/L of guide	± 2.00
II. GATE	
i) <i>Side and Top Seal Seat:</i>	
a) Alignment parallel to flow	± 0.50
b) Coplaneness	± 0.50
ii) <i>Side Guide shoe:</i>	
a) Alignment parallel to flow	± 1.50
iii) <i>Critical Dimensions:</i>	
a) Centre-to-centre distance between side seal plates	± 1.50
b) Face-to-face distance between side guides	± 1.50

ANNEX G

(Clause 8.9)

**RECOMMENDED VALUES OF COEFFICIENTS OF FRICTION
TO BE USED IN THE DESIGN OF SLIDE GATES**

<i>Sl No.</i>	<i>Material</i>	<i>Coefficient of Friction</i>	
		<i>Starting</i>	<i>Moving</i>
i)	Rubber seal on steel	1.50	1.20
ii)	Brass on bronze	0.40	0.25
iii)	Brass or bronze on steel	0.50	0.30
iv)	Steel on steel	0.60	0.40
v)	Stainless steel on steel or Stainless steel	0.50	0.30
vi)	Wood on steel	1.00	0.70
vii)	Gunmetal on gun metal	0.40	0.25
viii)	Fluorocarbon on stainless steel	0.20	0.15

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